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Title: La Cumbre Update: Motivation, Objectives, and Progress

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# La Cumbre Update

**Motivation, Objectives, and Progress**  
**Aug 2017 HED Council Meeting**



**N. E. Lanier**

August 31, 2017



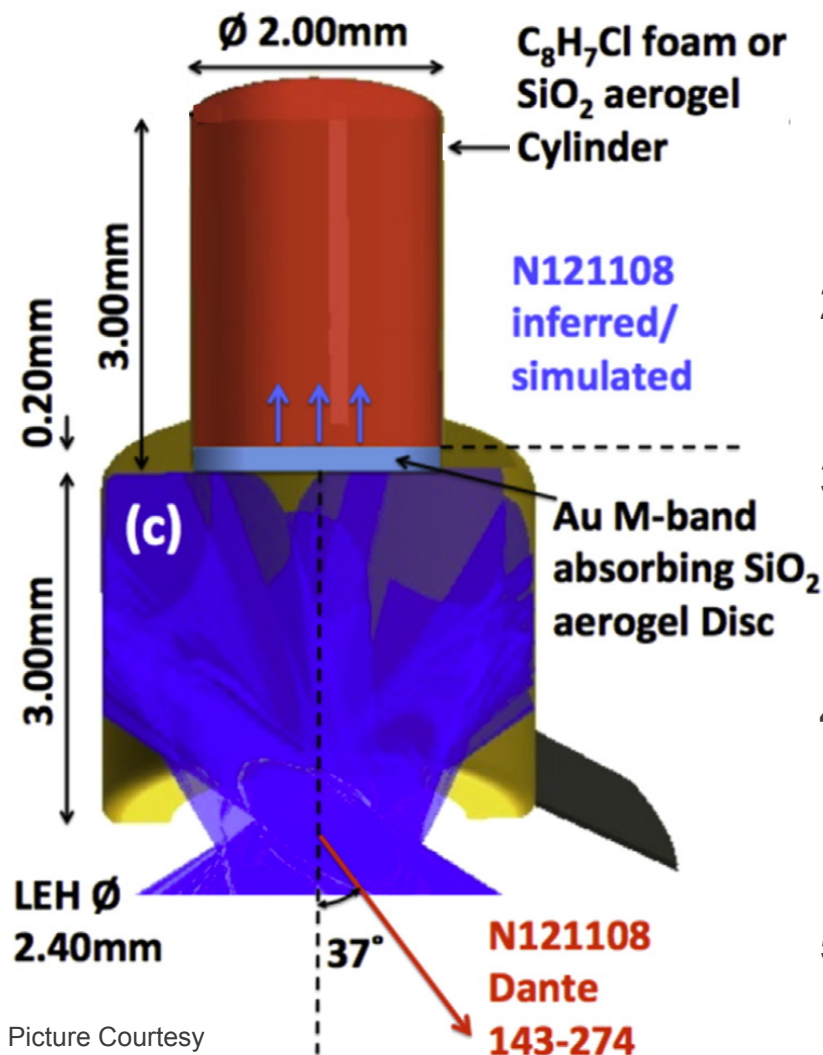
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# Summary

- We have completed implementation of a laser package in LANL's principal AGEX design code, Cassio.
- Although we have greatly improved our target characterization and uncertainty quantification, we remain unable to satisfactorily simulate the NIF Pleiades data.
- La Cumbre will reduce source uncertainty by providing absolute **magnitude** and **isotropy** measurements of the hohlraum's M-band and thermal tail emission.
  - Method has been successfully demonstrated *Rev. Sci. Instrum.* **87** 11D621 (2016)
  - Data is also instrumental in validating Cassio's new laser capability
- Designs of future radiation flow experiments will lack credibility until our laser predictions are constrained by experiments and the Pleiades discrepancy is understood.



# The Pleiades data remains poorly understood.

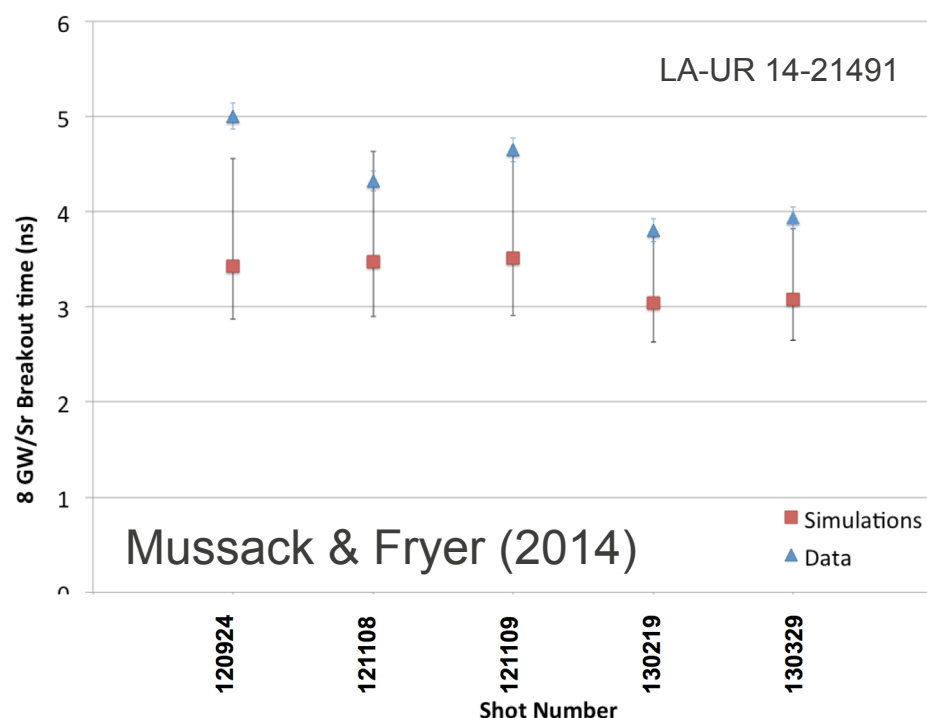


Picture Courtesy  
of Moore 2015.

- 1) "IMC transport approximations are in good agreement with the measured data provided that  $\epsilon$  [internal energy] is increased by 20%" A. Moore et al., *Journal of Quant Spect and Rad Trans*, 159 19-28 (2015).
- 2) "NYM simulations [under-predict] the radiation wave arrival by  $\sim 22\%$ " T. Guymer et al. *Phys. Plasmas* 22, 043303 (2015).
- 3) "The errors in the break-out time are asymmetric, leading to a systematic bias in the observed data." C. L. Fryer et al. *High Energy Density Physics* 18, 45-54 (2016).
- 4) "For an arbitrary factor of  $M_k$  [opacity scaling],  $M_{\text{EOS}}$  [the EoS scaling factor] is known to 1.2%." T. Guymer et al. *Phys. Plasmas* 22, 043303 (2015).
- 5) "The x-ray assembly is capable of determining line-averaged density variations near the 1% level" N. E. Lanier et al., *Rev. Sci. Instrum.* 83 (2012).

# While important, it is improbable that the asymmetric bias argument can explain away our discrepancy.

Lasnex linked to Cassio also shows significant breakout discrepancy.

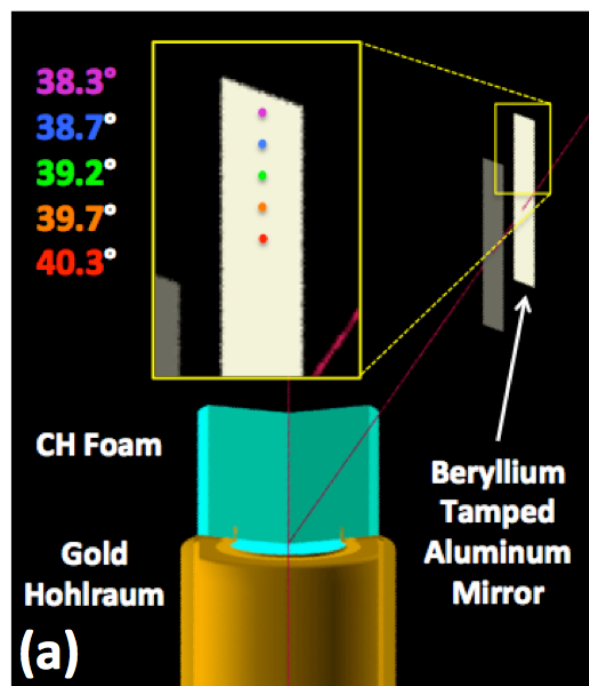


Better source characterization is required.

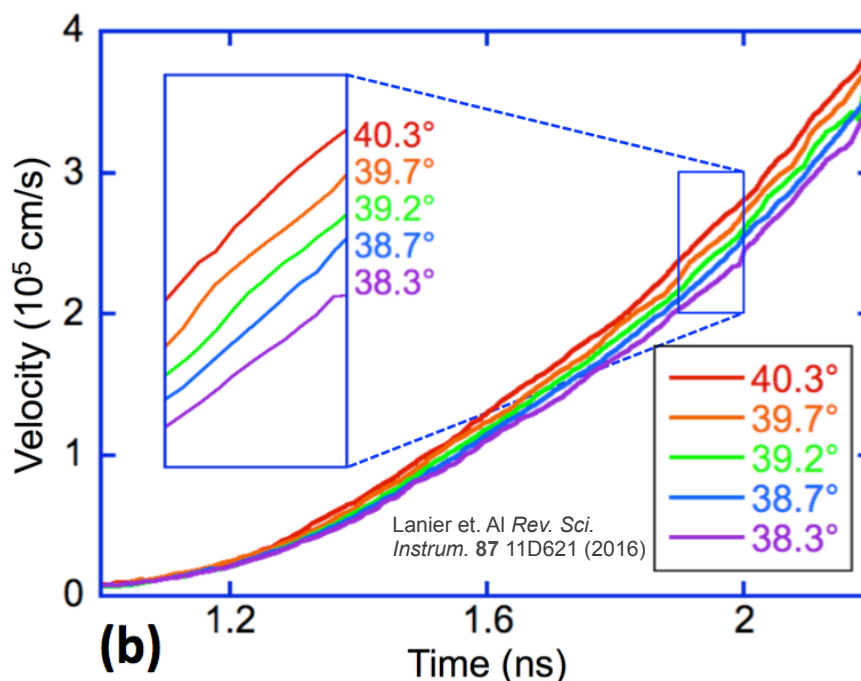
- Why are the simulations always fast by about the same magnitude?
- If errors are large and truly independent then where is the randomness?
- Is it possible that we underestimate the foam's internal energy by 20% when the mass is known to 1%?
- **Can these explanations be credible when the source remains so poorly understood?**

# La Cumbre will measure isotropy and magnitude of M-band emission and lower our uncertainty in the Pleiades source.

Thermal radiation preferentially filtered removed

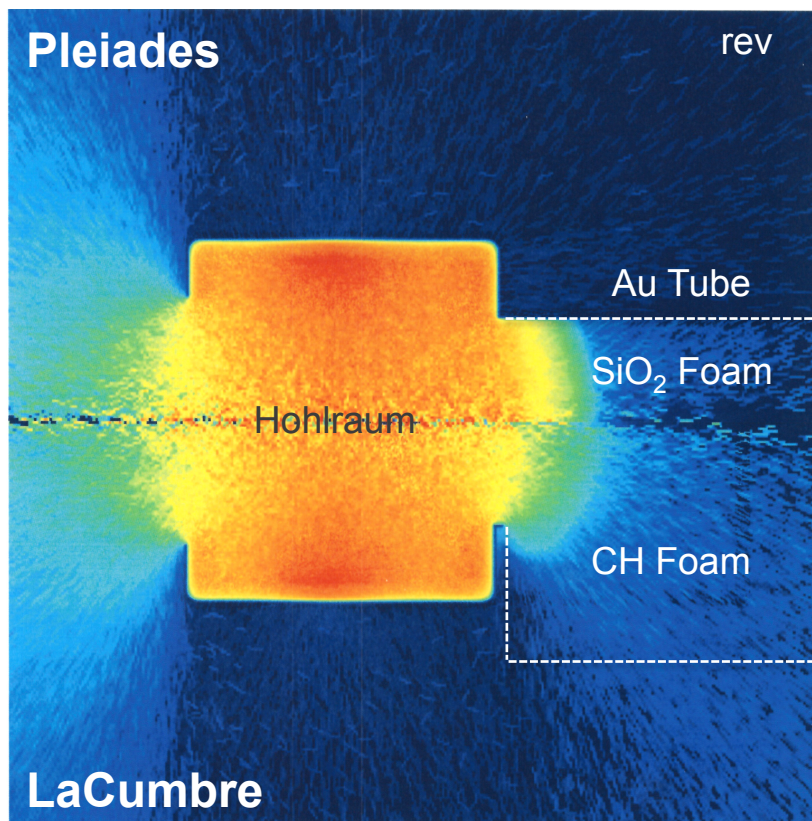


Aluminum interface velocity imaged with VISAR.

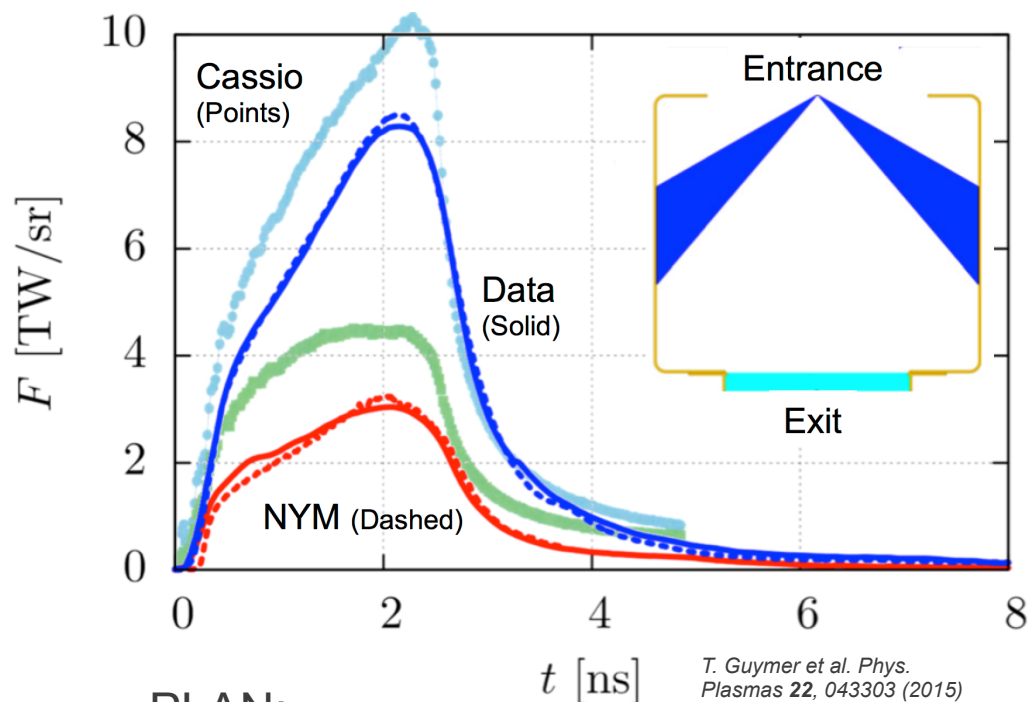


Proof-of-principal experiments have demonstrated a minimum resolvable velocity of  $< 50$  cm/s and  $\sim 0.5$  degree angular resolution.

# New laser package in Cassio shows promise, however, further optimization is required.



Cassio over predicts drive from Pleiades Phase I experiments.

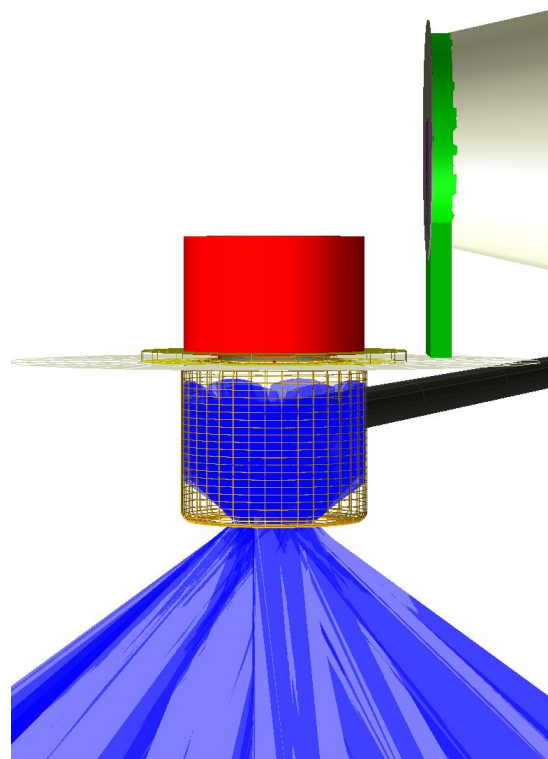


PLAN:

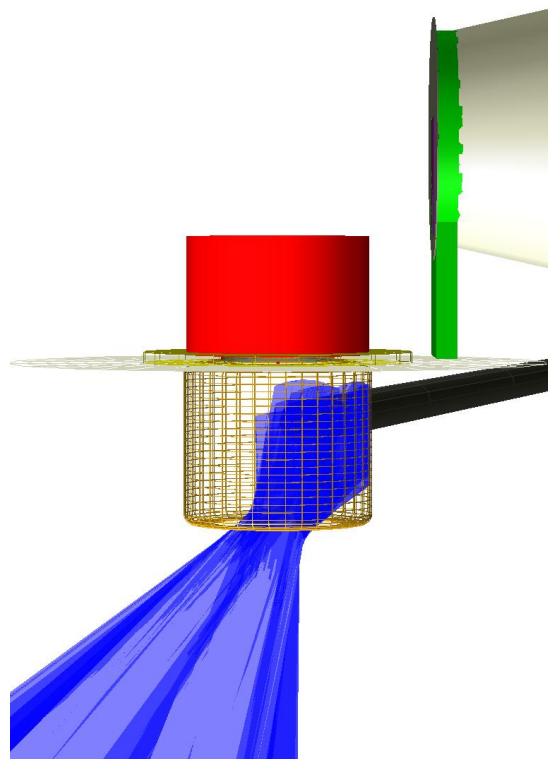
- Constrain source with data,
- update predictions for La Cumbre,
- reassess Pleiades.



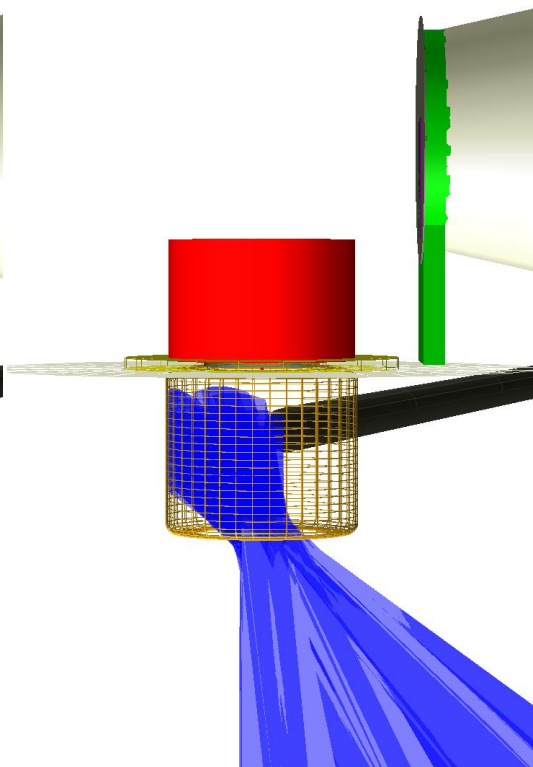
# Shot plan for January 2018 will isolate thermal tail and M-band components of source spectrum



Full Power

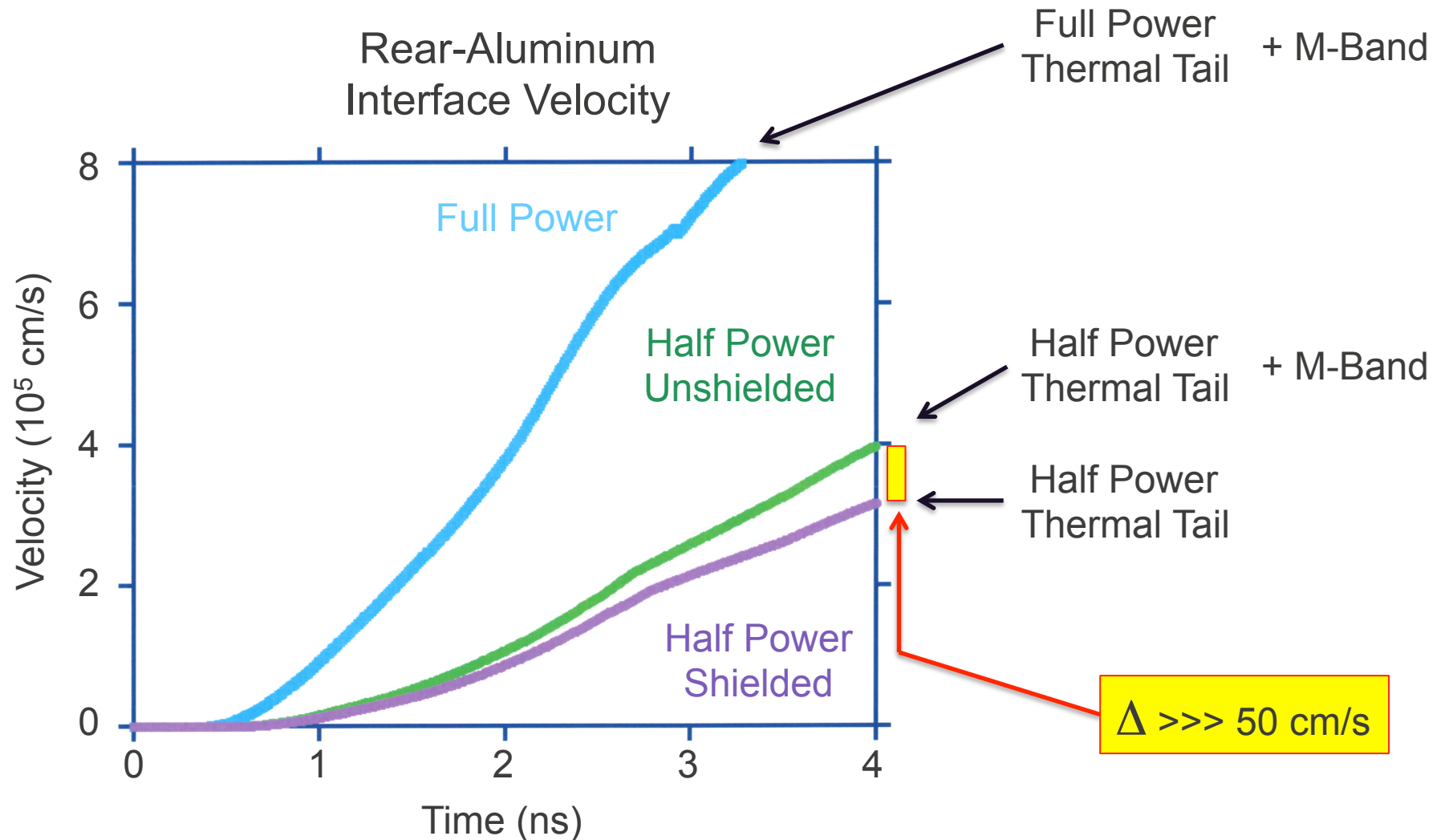


Half Power  
Shielded



Half Power  
Unshielded

# Cassio predictions coupled with experimental results show source differences are clearly resolvable.

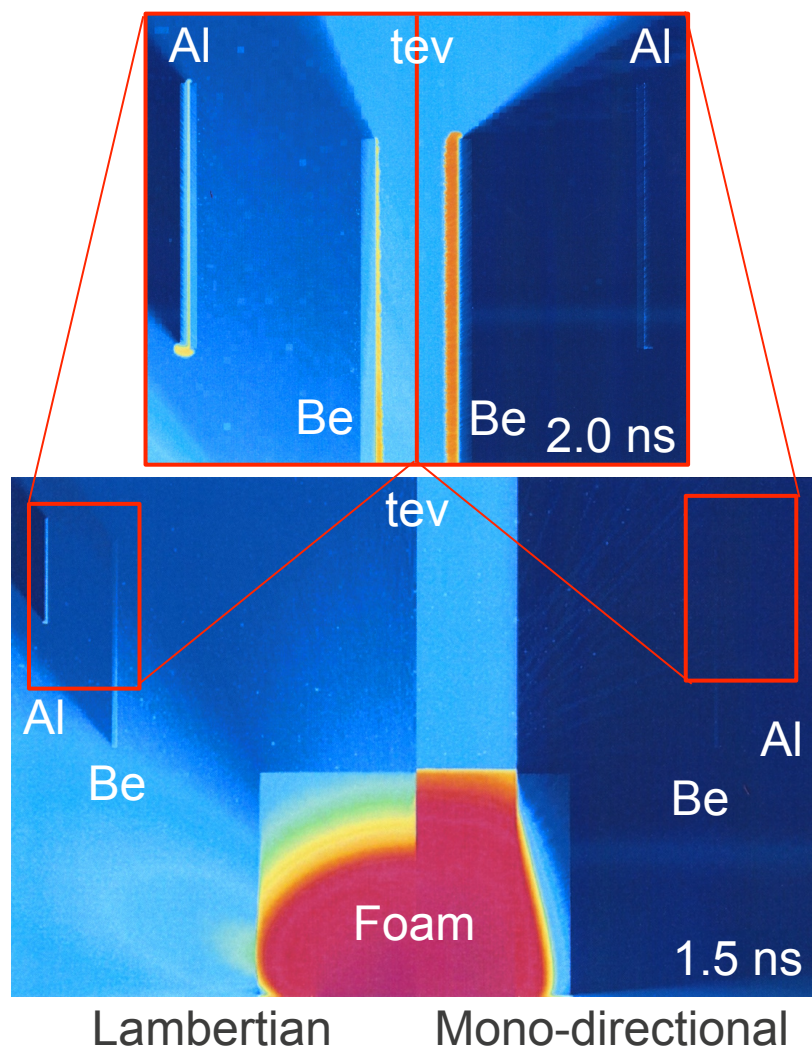


# Spring PRP Comments

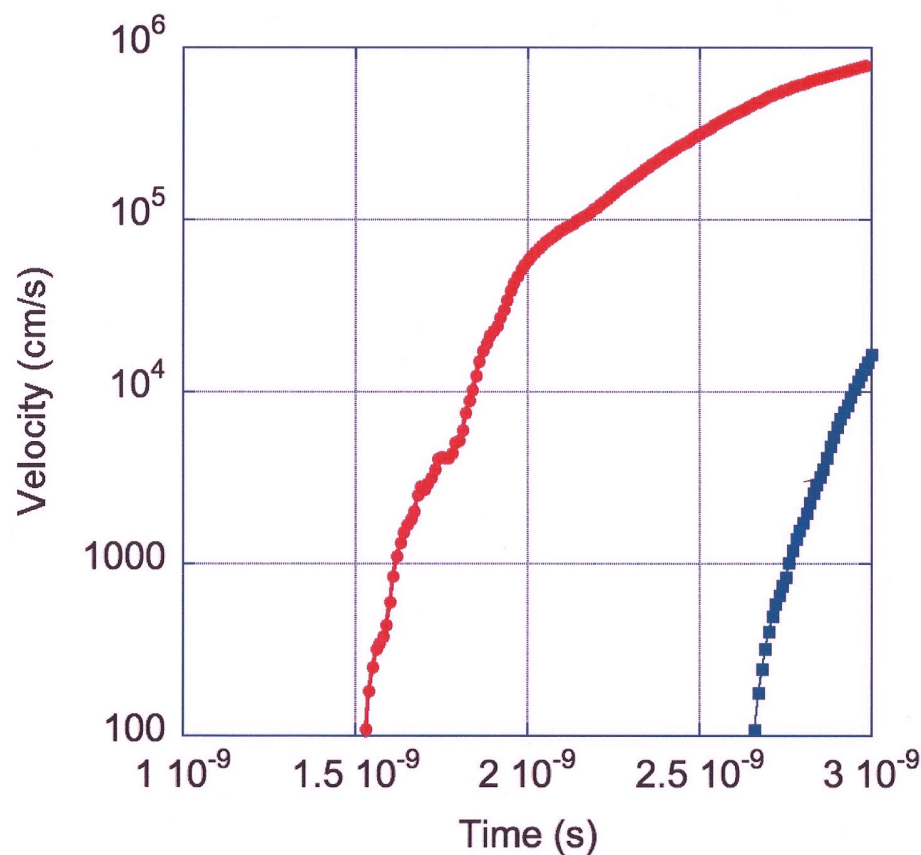
## P-000152 - Radiation Drive

- **Getting angular distribution of M-band in a hohlraum would be useful.**
- **Proposed method of Al-witness plate looks interesting, though we are concerned about the foam scatterer that is in between the hohlraum and the diagnostic.**
- **Is it clear that it is only M-band detected in this manner. Can we cross calibrate this with Dante at the same line of sight?**

# Cassio simulations predict scattering from the foam does not significantly diffuse the isotropy information

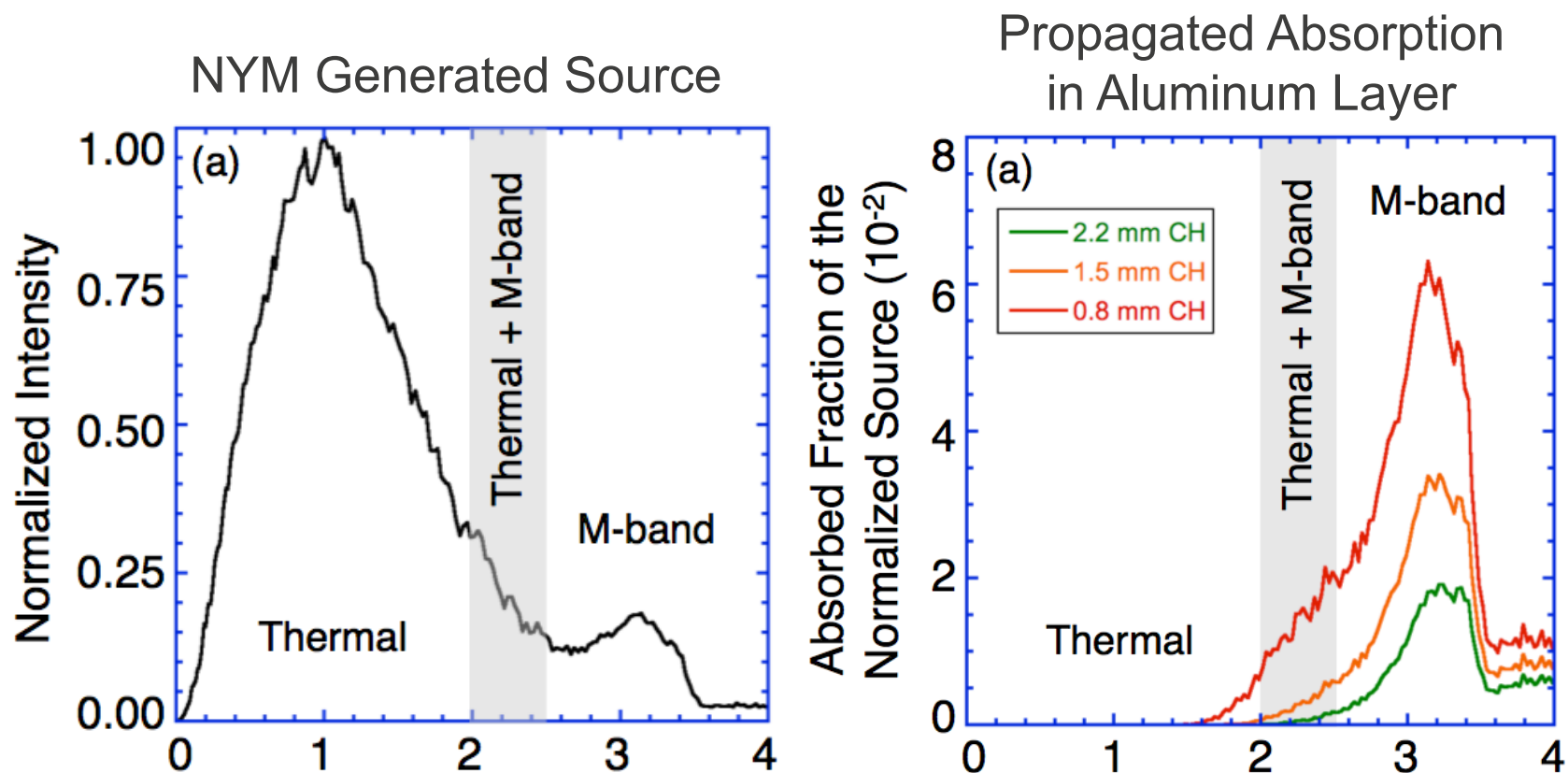


Scattering induced motion accounts for < 2% of aluminum interface velocity late in time.





# Propagating an illustrative source shows the aluminum layer dominantly absorbs energies above 1.5 keV.



If similar lines of sight are chosen it will be possible to cross-calibrate result with Dante and Virgil.

# One last note: LANL continues to improve methodically its HED design and experimental capabilities

- (2011) Frequency Dependent Source capability in Cassio for better linking with LASNEX drive simulations
- (2012) Density Characterization ~ 1% resolution per part measurement
- (2015) Detailed study quantifying the interactions between uncertainties in Pleiades experiment
- (2016) Demonstration of novel PoP source characterization experiments (Cepheus)
- (2016) Direct-drive Laser package implementation in Cassio, hohlraum capability in 2017.
- (2017) Non-invasive quantification of radiatively heated material (Coax on OMEGA)
- (2018) La Cumbre is one more essential component in our pursuit of predictive capability in radiation flow.

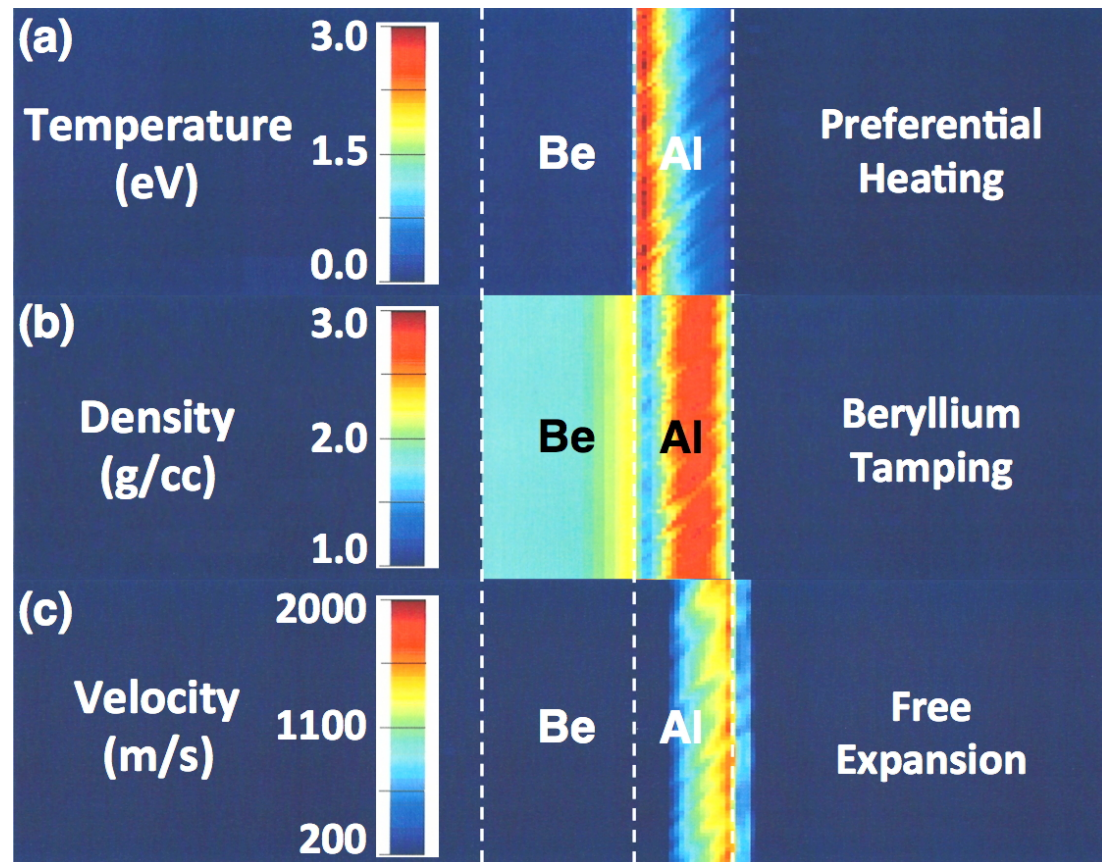
Although LANL's HED capabilities are relatively immature, our approach to radiation flow experiments has been **reasoned** and **methodical**.

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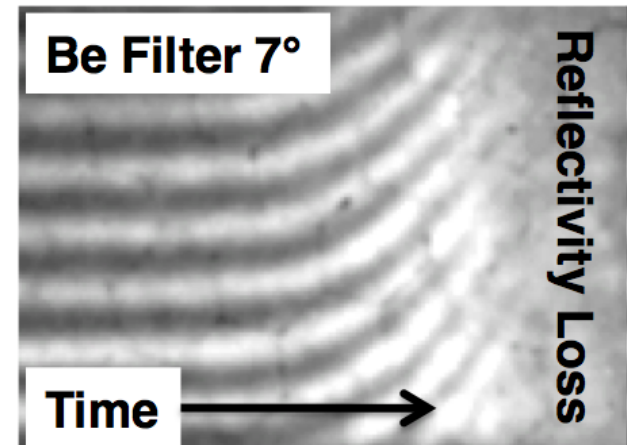
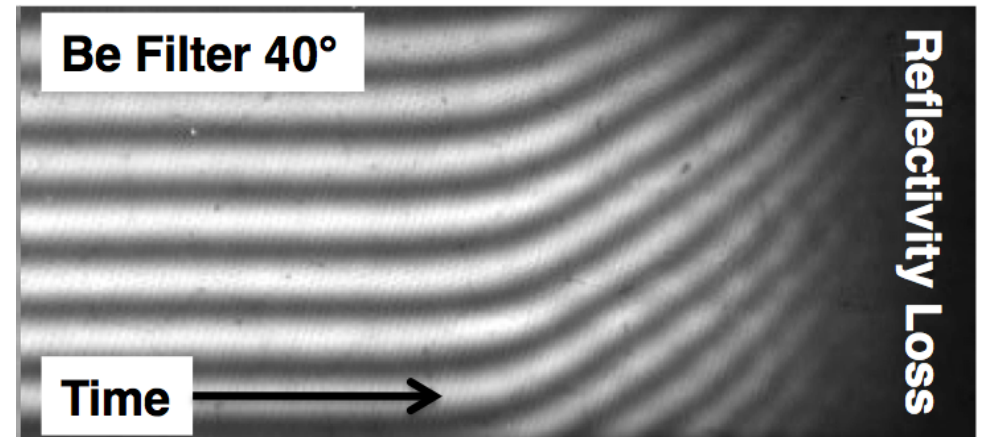
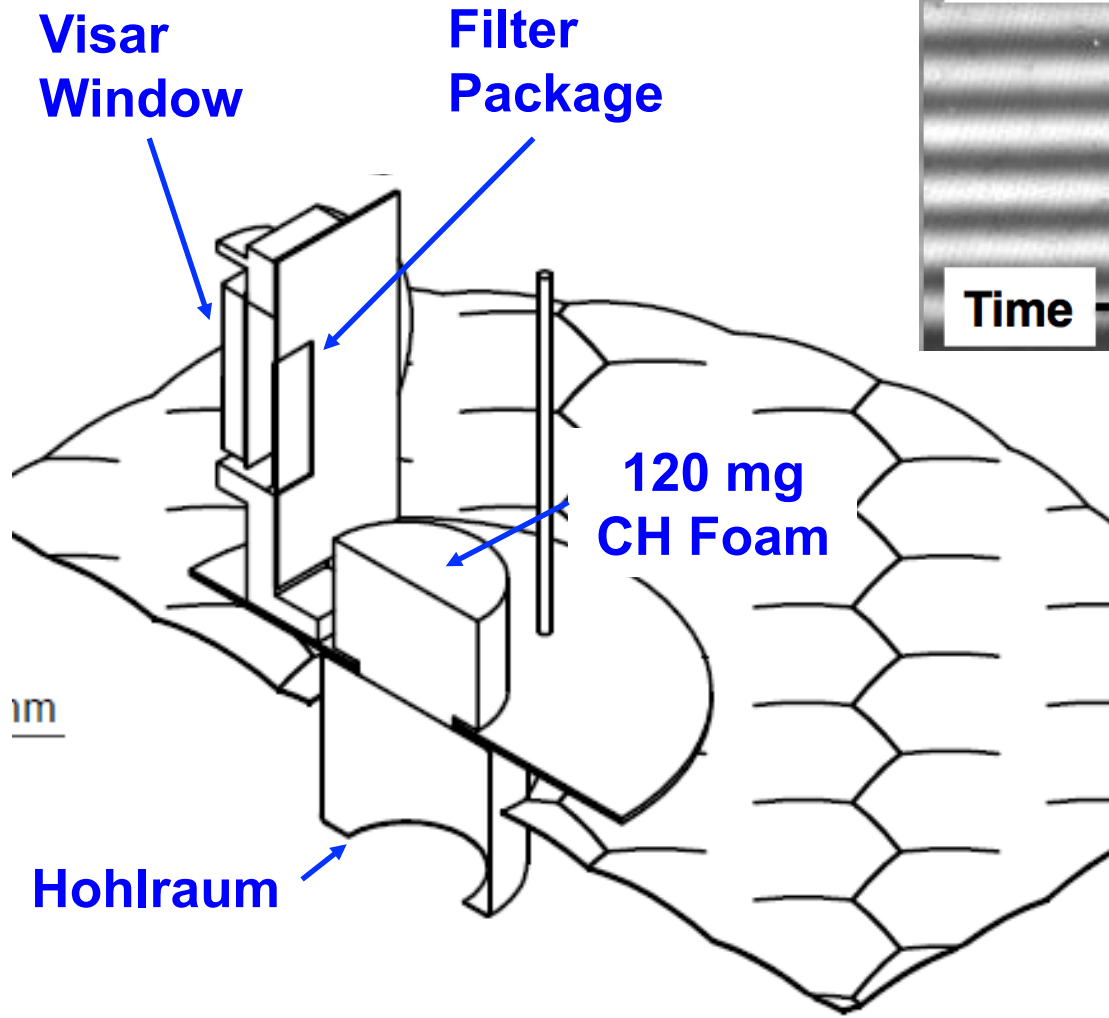
# Backup Slides

# Cassio simulations showing the tamped aluminum layer at 40°, 1.3 ns after the onset of laser drive



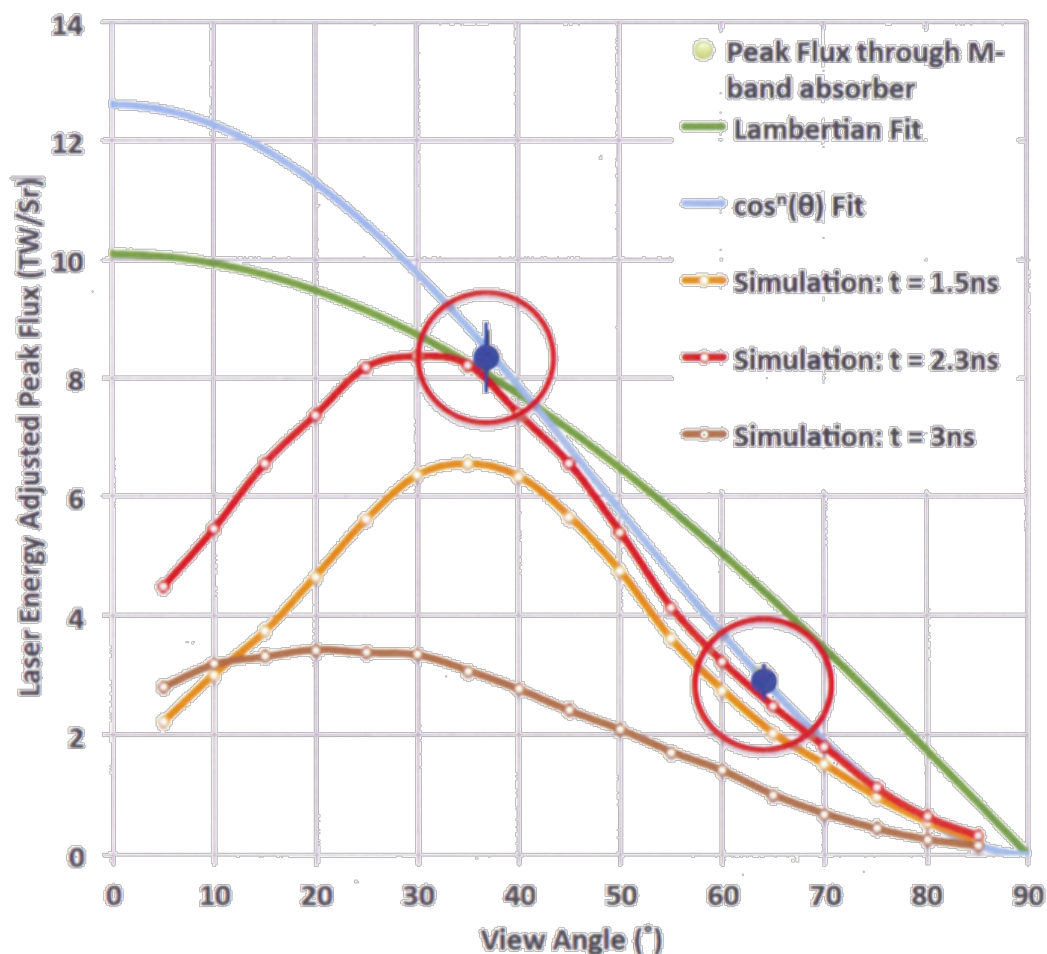
- (a) The radiation is preferentially absorbed in the aluminum reaching 1-3 eV temperatures
- (b) Unable to expand into the cold beryllium, the pressure builds and the aluminum layer expands outward.
- (c) The free expansion of the aluminum surface is measured with VISAR.

**La Cumbre will measure anisotropy of M-band emission – help lower our uncertainty in the Pleiades source.**





# Limited flexibility in DANTE views complicate efforts to validate hohlraum source predictions.

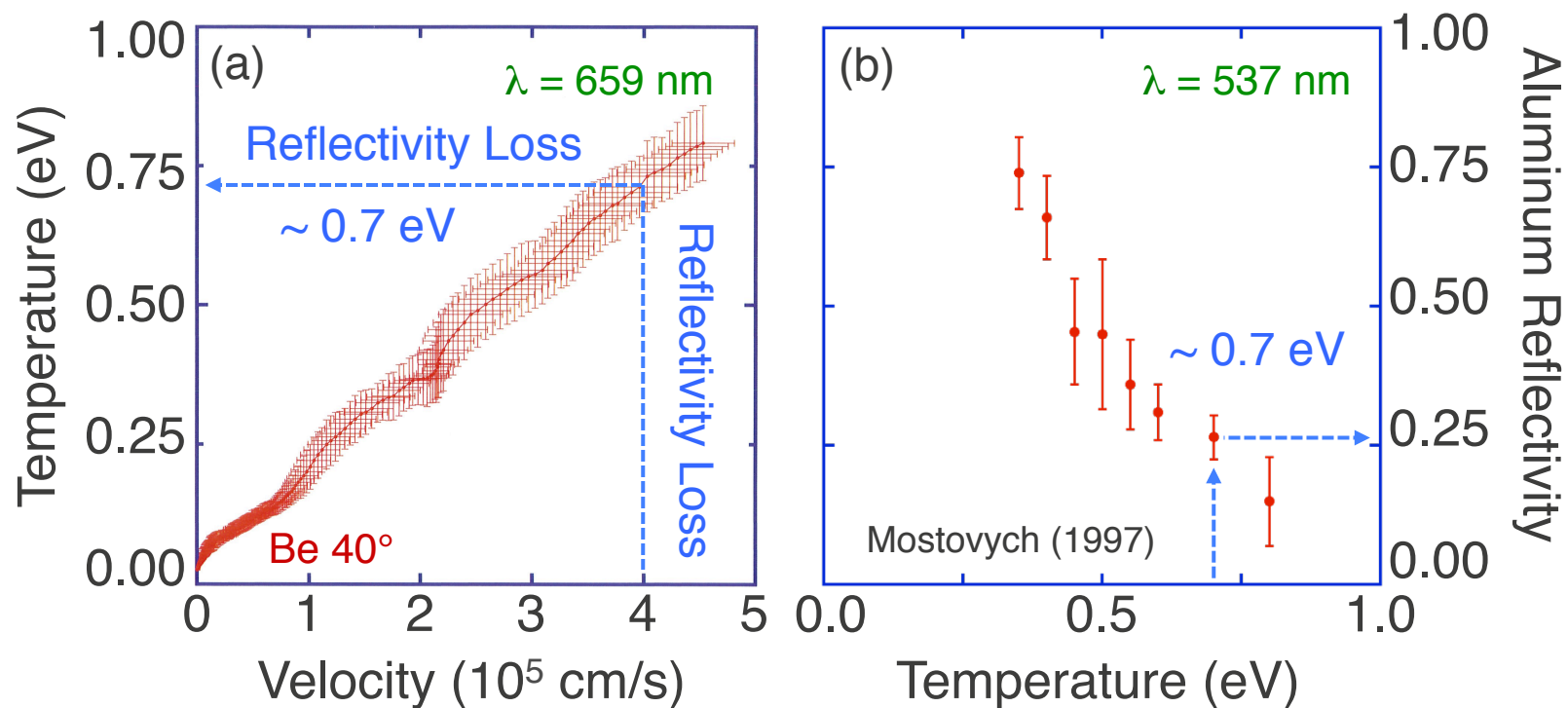


Pleiades on NIF studied supersonic radiation flow down simple tube.

Using DANTE data, both NYM and LASNEX generated sources that **over predicted propagation velocities.**

Drive uncertainty remains possible cause of this discrepancy.

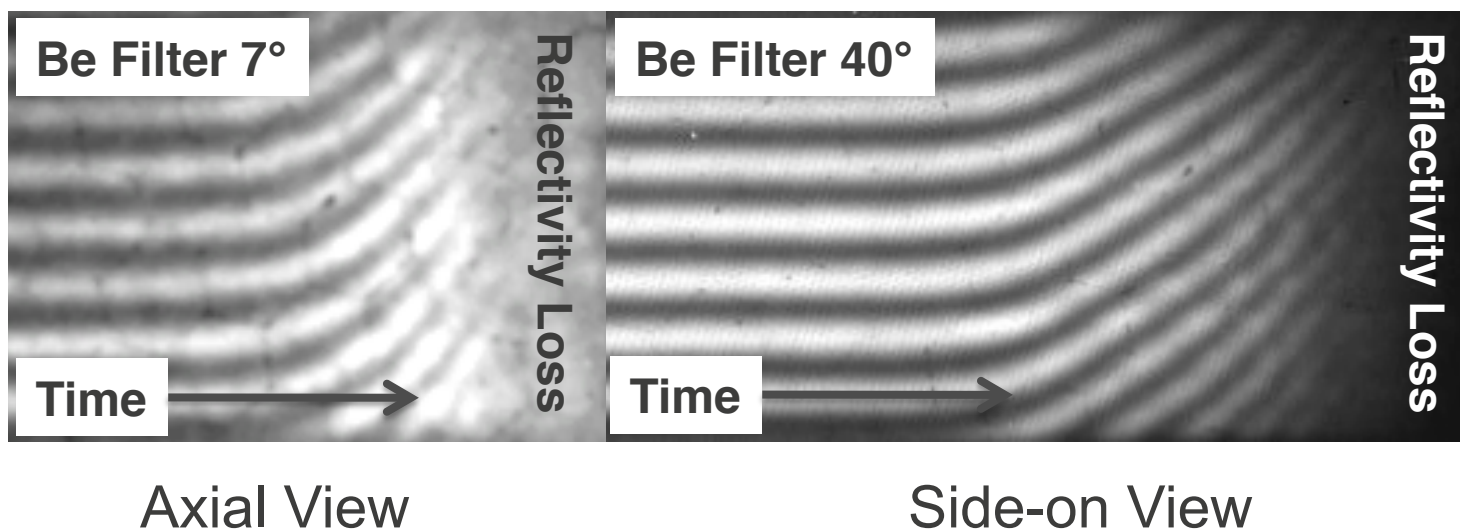
# Timing of reflectivity loss holds important information about state of expanding aluminum surface.



Signal is lost when aluminum surface reaches .5-.7 eV.



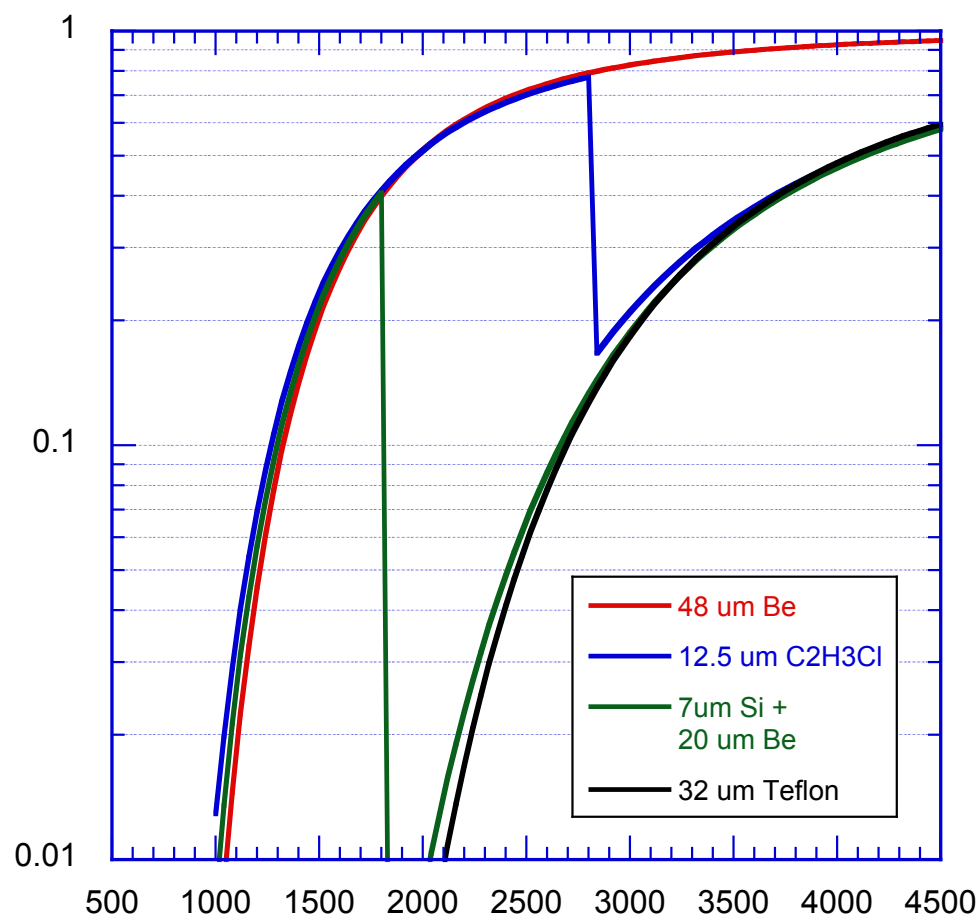
**Axial view shows faster acceleration and sooner reflectivity loss that observed at larger angles.**



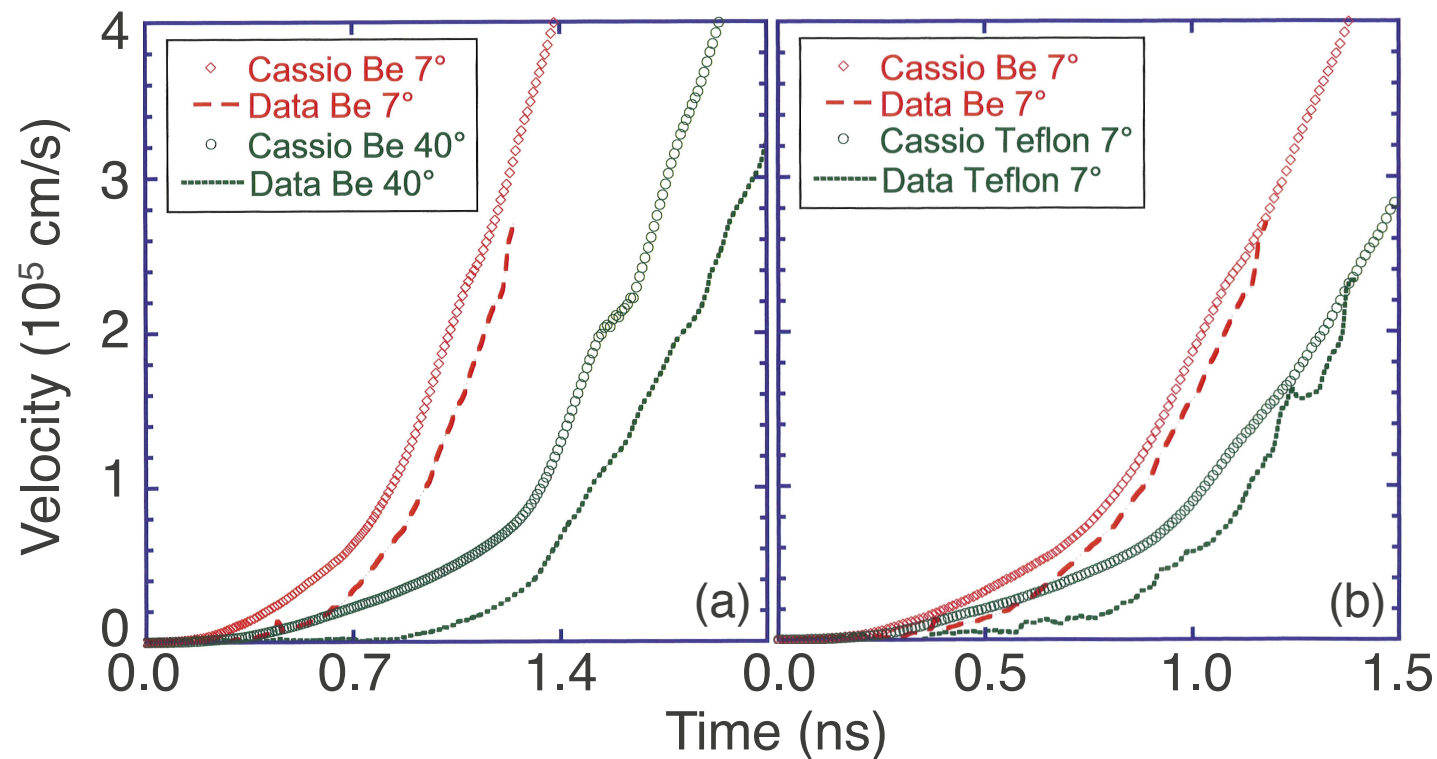
Caution: Both **anisotropic emission** and **geometric effects** are included in this measurement.

Separating the two contributors will require additional feedback from more realistic source models.

**Future experiments could employ silicon and chlorine filters to enhance spectral discrimination.**



# Cassio simulations show more early motion and an overall lower quantity of gold M-band flux.



More analysis required but these data would indicate that NYM and LASNEX drives over-predict the radiative output of the Pleiades platform.